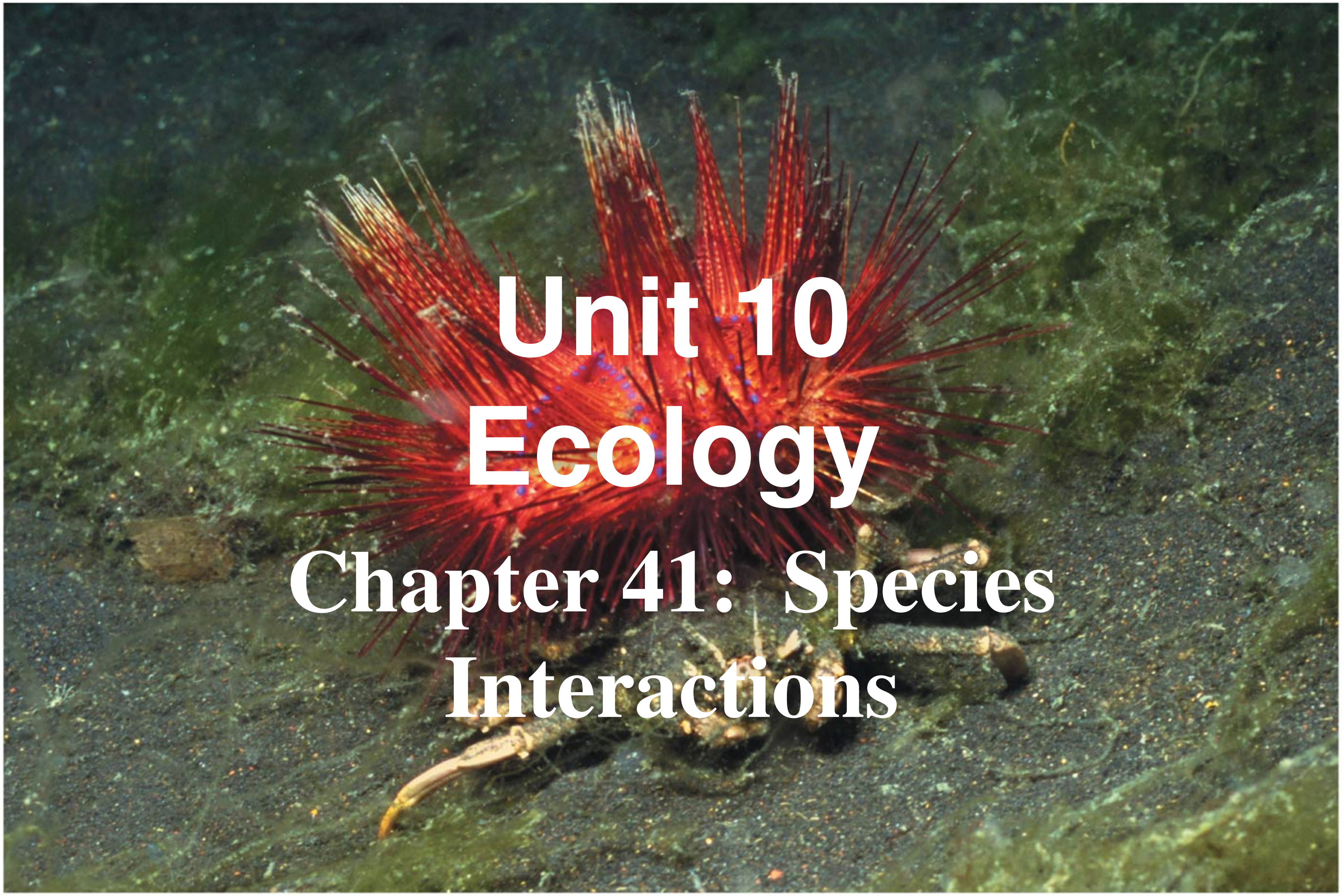


Unit 10
Ecology

Chapter 41: Species Interactions

Overview: Communities in Motion

- A biological **community** is an assemblage of populations of various species living close enough for potential interaction
  - For example, the "carrier crab" carries a sea urchin on its back for protection against predators

Concept 41.1: Interactions within a community may help, harm, or have no effect on the species involved

- Ecologists call relationships between species in a community **interspecific interactions**
  - Examples are
    - Competition
    - Predation
    - Herbivory
    - Symbiosis
      - Parasitism, mutualism, and commensalism
    - Facilitation

- Interspecific interactions can affect the survival and reproduction of each species
  - Effects can be summarized as
    - Positive (+)
    - Negative (–)
    - No effect (0)

Competition

- **Interspecific competition** occurs when species compete for a resource that limits their growth or survival
  - (–/– interaction)

Competitive Exclusion

- Strong competition can lead to **competitive exclusion**
  - Local elimination of a competing species
- The competitive exclusion principle states that two species competing for the same limiting resources cannot coexist in the same place

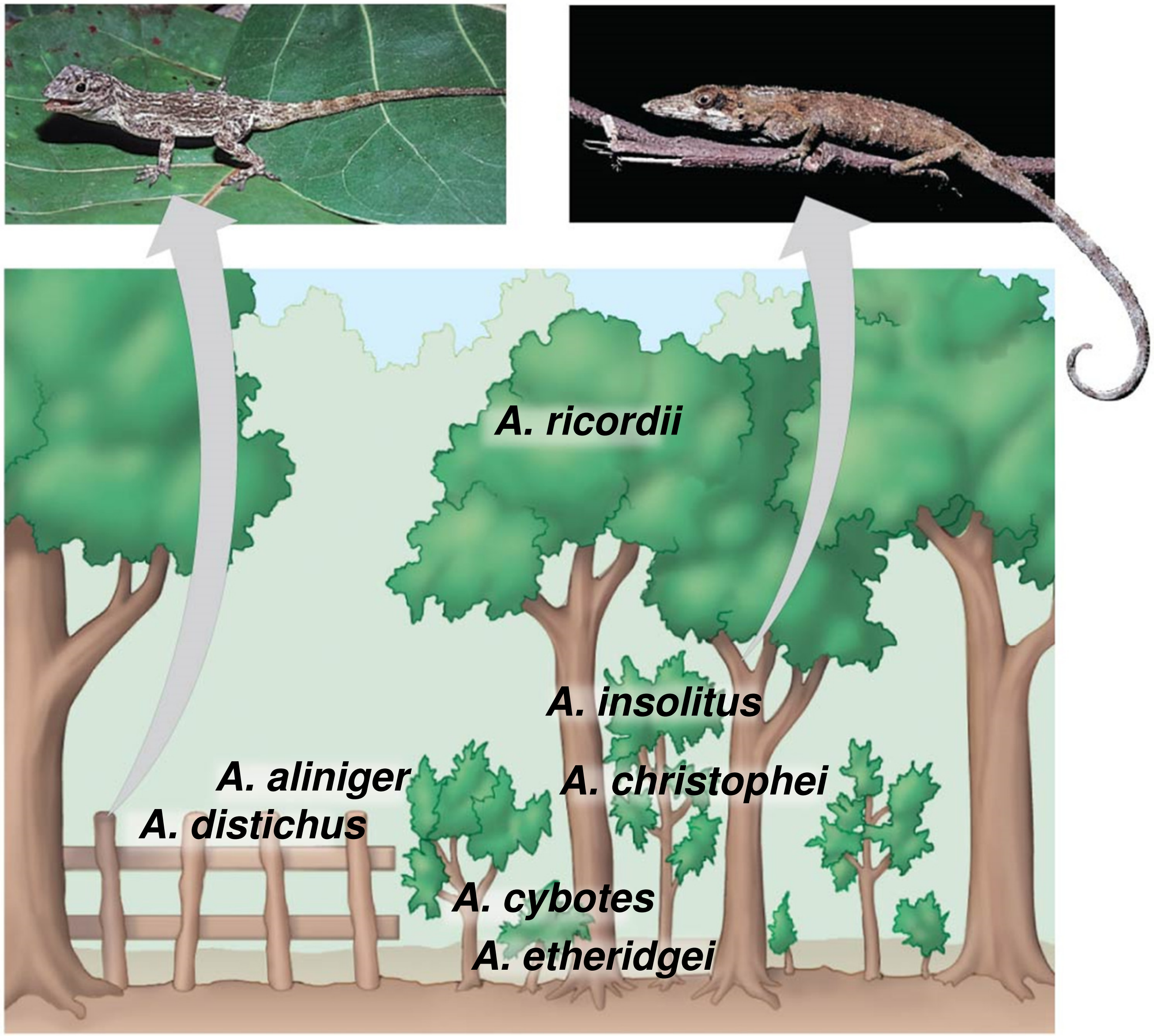
Ecological Niches and Natural Selection

- An **ecological niche** is the specific set of biotic and abiotic resources used by an organism
  - Can also be thought of as an organism's ecological role
  - Habitat = "address"; niche = "profession"
- Ecologically similar species can coexist in a community if there are one or more significant differences in their niches
- **Resource partitioning** is differentiation of ecological niches, enabling similar species to coexist in a community

Figure 41.2

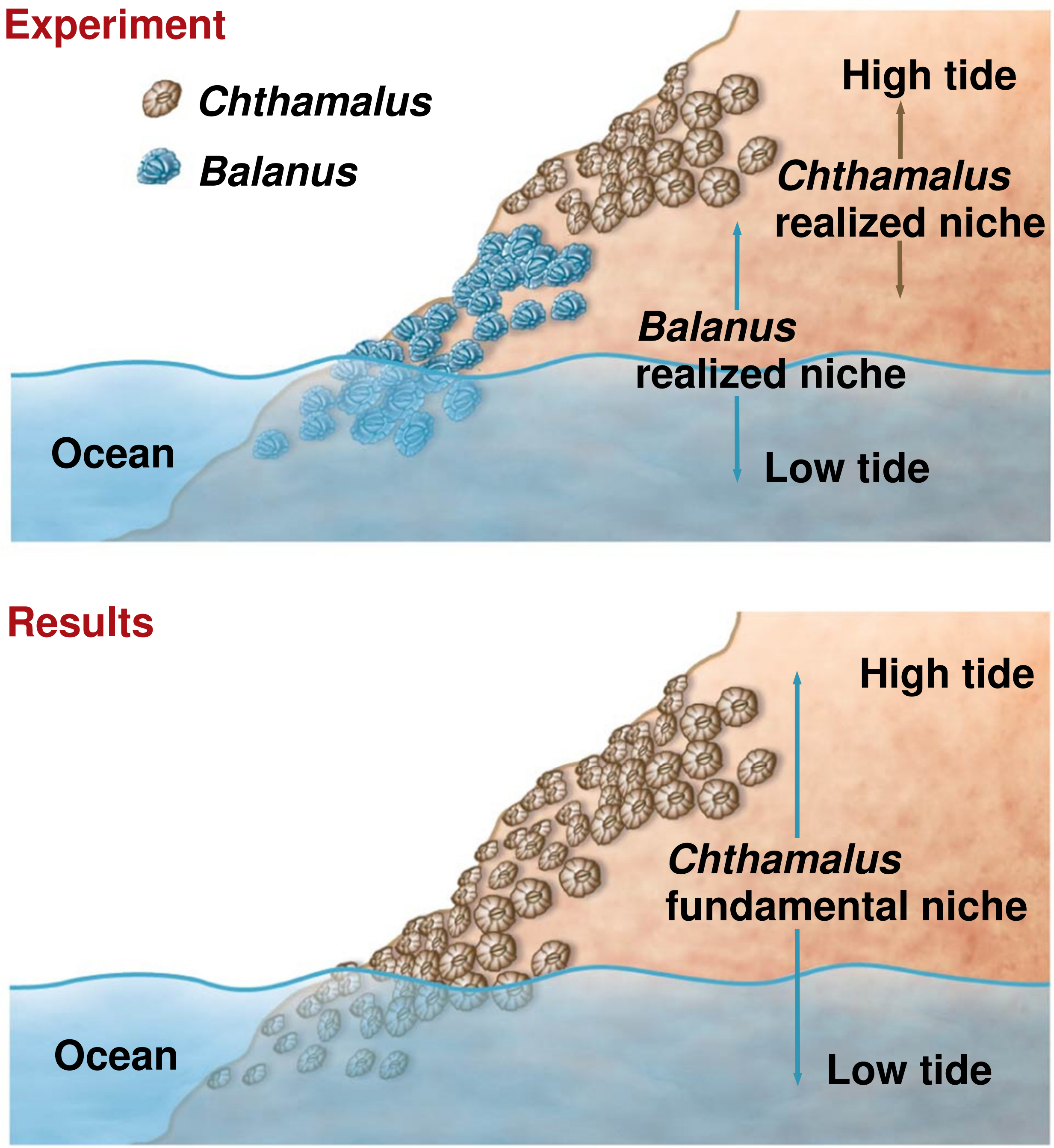
A. distichus **perches on fence posts and other sunny surfaces.**

A. insolitus **usually perches on shady branches.**



- A species’ *fundamental niche* is the niche potentially occupied by that species
- A species’ *realized niche* is the niche actually occupied by that species
- As a result of competition, a species’ fundamental niche may differ from its realized niche
  - For example, the presence of one barnacle species limits the realized niche of another species

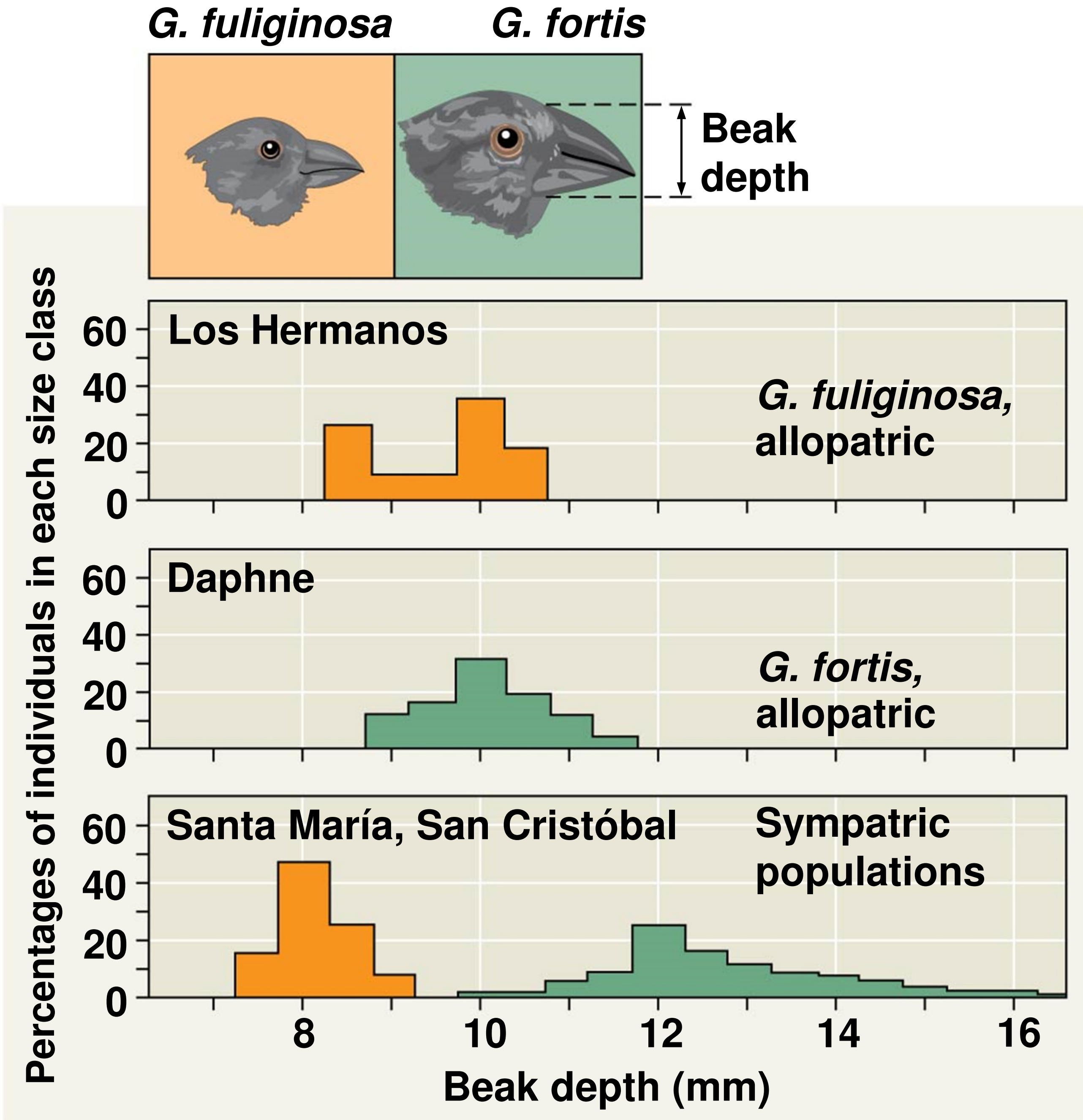
Figure 41.3


Experiment
Chthamalus
Balanus
High tide
Chthamalus
realized niche
Balanus
realized niche
Low tide
Ocean
Results
High tide
Chthamalus
fundamental niche
Low tide
Ocean

Character Displacement

- **Character displacement** is a tendency for characteristics to be more divergent in sympatric populations of two species than in allopatric populations of the same two species
  - Review:
    - Allopatric = geographically separate
    - Sympatric = geographically overlapping
  - An example is variation in beak size between populations of two species of Galápagos finches

Figure 41.4



G. fuliginosa
G. fortis
Beak
depth
Los Hermanos
G. fuliginosa,
allopatric
Daphne
G. fortis,
allopatric
Santa María, San Cristóbal
Sympatric
populations
Percentages of individuals in each size class
60
40
20
0
8
10
12
14
16
Beak depth (mm)

Predation

- **Predation** refers to an interaction in which one species, the predator, kills and eats the other, the prey
  - (+/- interaction)
- Adaptations of predator and pry tend to be refined through natural selection
- Some feeding adaptations of predators are
  - Acute senses
  - Claws, teeth, stingers, and poison
  - Speed or camouflage

- Prey display various defensive adaptations
  - Behavioral defenses include hiding, fleeing, forming herds or schools, and active self-defense
  - Animals also have morphological and physiological defense adaptations
    - **Cryptic coloration**, or camouflage, makes prey difficult to spot
    - Mechanical or chemical defenses like quills, foul odors, or toxins
      - Animals with effective chemical defenses often exhibit bright warning coloration, called **aposematic coloration**

- In some cases, a prey species may gain significant protection by mimicking the appearance of another species
  - In **Batesian mimicry**, a palatable or harmless species mimics an unpalatable or harmful model
  - In **Müllerian mimicry**, two or more unpalatable species resemble each other
- Many predators also use mimicry
  - Ex: Alligator snapping turtle has a tongue that resembles a wiggling worm

Figure 41.5

(a) Cryptic coloration

► Canyon tree frog

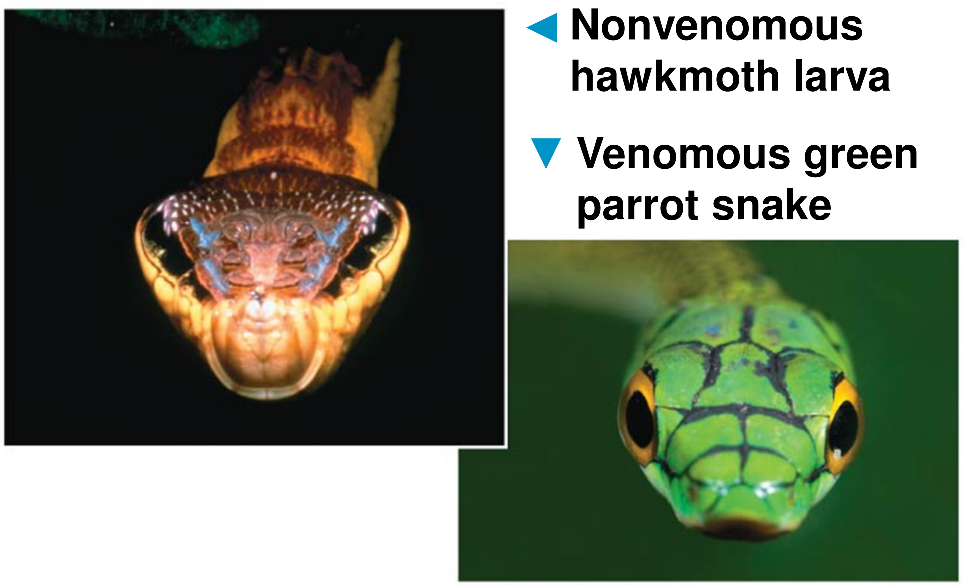
(b) Aposematic coloration

► Poison dart frog

(c) Batesian mimicry: A harmless species mimics a harmful one.

◄ Nonvenomous hawkmoth larva

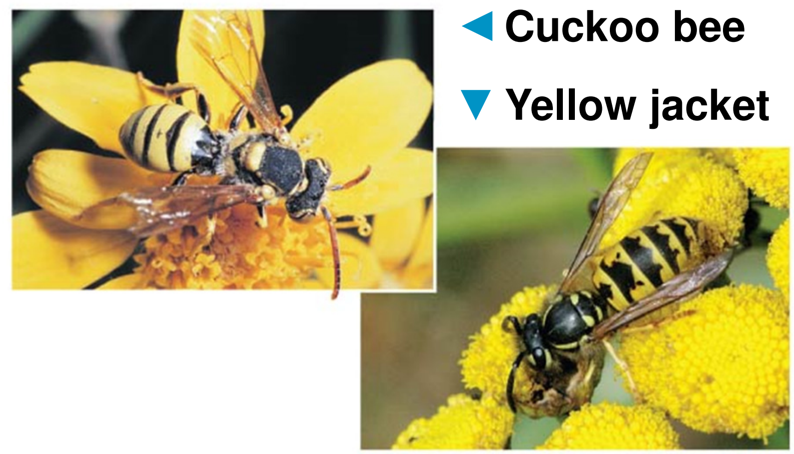
▼ Venomous green parrot snake



(d) Müllerian mimicry: Two unpalatable species mimic each other.

◄ Cuckoo bee

▼ Yellow jacket



Herbivory

- **Herbivory** refers to an interaction in which an herbivore eats parts of a plant or alga
  - (+/- interaction)
- In addition to behavioral adaptations, some herbivores may have chemical sensors or specialized teeth or digestive systems
- Plant defenses include chemical toxins and protective structures

Symbiosis

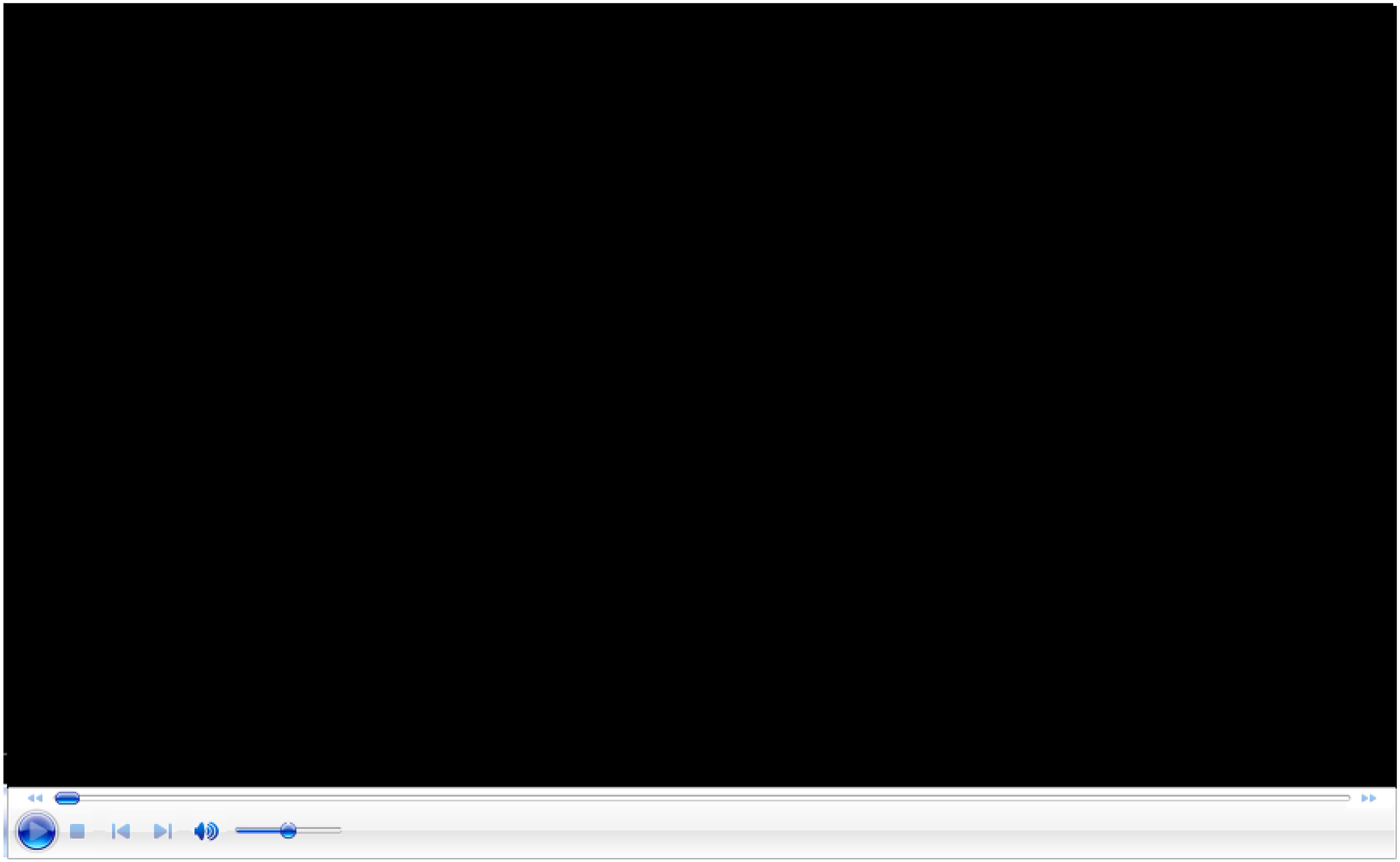
- **Symbiosis** is a relationship where two or more species live in direct and intimate contact with one another

Parasitism

- In **parasitism** one organism, the **parasite**, derives nourishment from another organism, its **host**, which is harmed in the process
  - (+/- interaction)
- Parasites that live within the body of their host are called **endoparasites**
  - Ex: Tapeworms
- Parasites that live on the external surface of a host are **ectoparasites**
  - Ex: Ticks

Mutualism

- Mutualistic symbiosis, or mutualism, is an interspecific interaction that benefits both species
  - (+/+ interaction)
  - Examples:
    - Nitrogen fixation by bacteria for legumes
    - Cellulose digestion by microorganisms in digestive systems of ruminants
    - Photosynthesis by algae in corals
- Mutualisms sometimes involve coevolution of related adaptations in both species



Video: Clownfish and Anemone

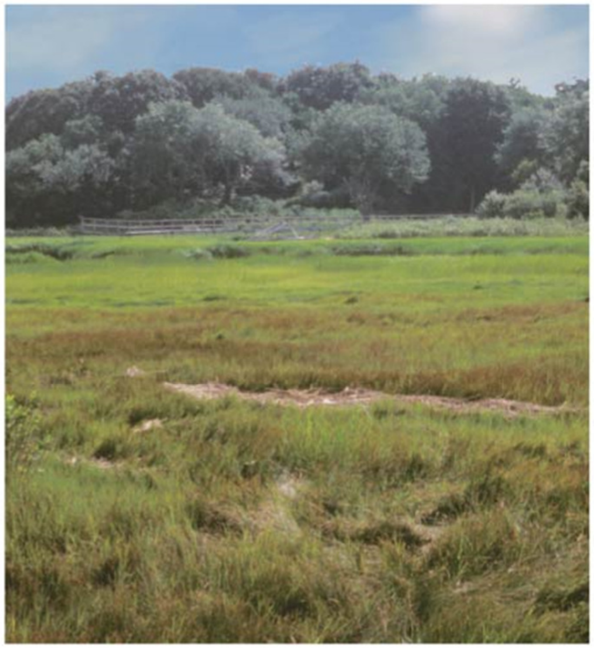
Commensalism

- In **commensalism**, one species benefits and the other is neither harmed nor helped
  - (+/0 interaction)
  - Ex: “Hitchhiking” species
- Commensal interactions are hard to document in nature because any close association likely affects both species

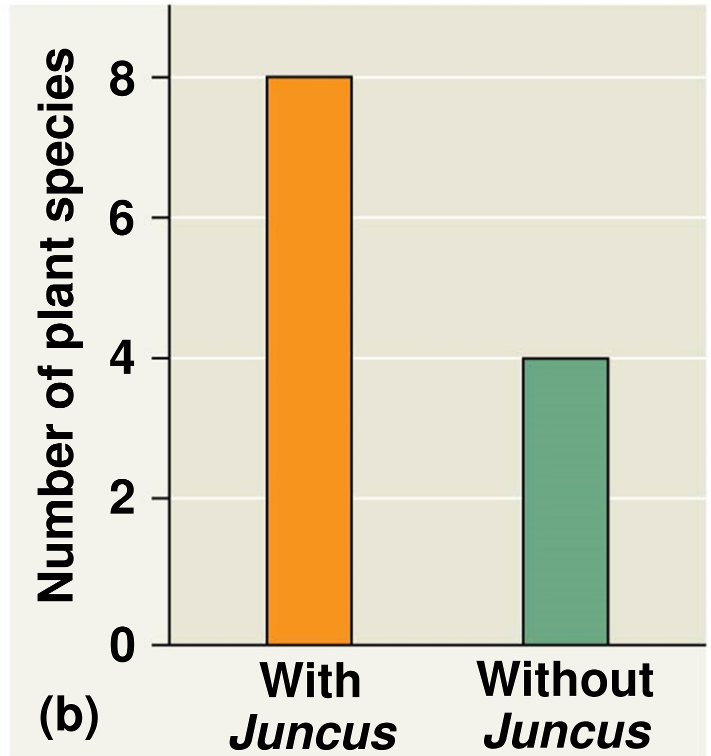
Facilitation

- **Facilitation** is an interaction in which one species has positive effects on another species without direct and intimate contact
  - (+/+ or 0/+)
  - Particularly common in plants ecology
    - Ex: The black rush makes the soil more hospitable for other plant species

Figure 41.9



(a) Salt marsh with *Juncus* (foreground)



(b)

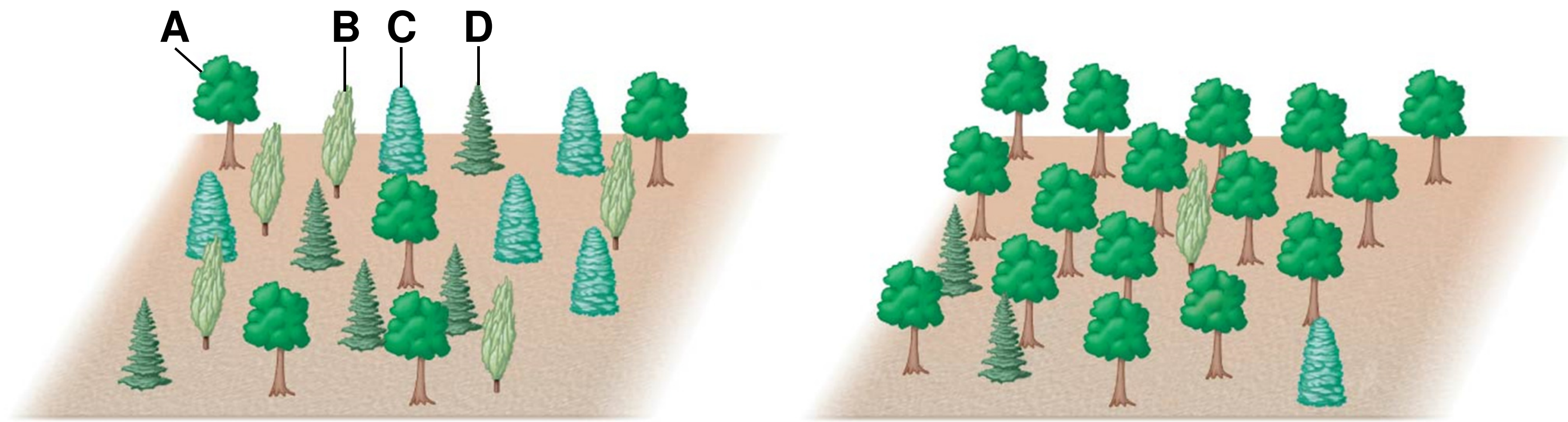
Concept 41.2: Diversity and trophic structure characterize biological communities

- Two fundamental features of community structure are species diversity and feeding relationships
- Sometimes a few species in a community exert strong control on that community's structure

Species Diversity

- **Species diversity** of a community is the variety of organisms that make up the community
- It has two components:
  - **Species richness** is the number of different species in the community
  - **Relative abundance** is the proportion each species represents of all individuals in the community
- Two communities can have the same species richness but a different relative abundance

Figure 41.10



Community 1
A: 25% B: 25% C: 25% D: 25%

Community 2
A: 80% B: 5% C: 5% D: 10%

Diversity and Community Stability

- Communities with higher diversity are
  - More productive and more stable in their productivity
  - Able to produce more consistent **biomass**
    - Total mass of all individuals in a population
  - Better able to withstand and recover from environmental stresses
  - More resistant to **invasive species**
    - Organisms that become established outside their native range

Trophic Structure

- **Trophic structure** is the feeding relationships between organisms in a community
  - Key factor in community dynamics
- **Food chains** are the pathways along which food energy is transferred from trophic level to trophic level
  - Link trophic levels from producers to top carnivores
    - From autotrophs (primary producers) to herbivores (primary consumers)
    - To carnivores (secondary, tertiary, quaternary consumers) and eventually to decomposers
- A **food web** is a branching food chain with complex trophic interactions
- Species may play a role at more than one trophic level

Figure 41.13

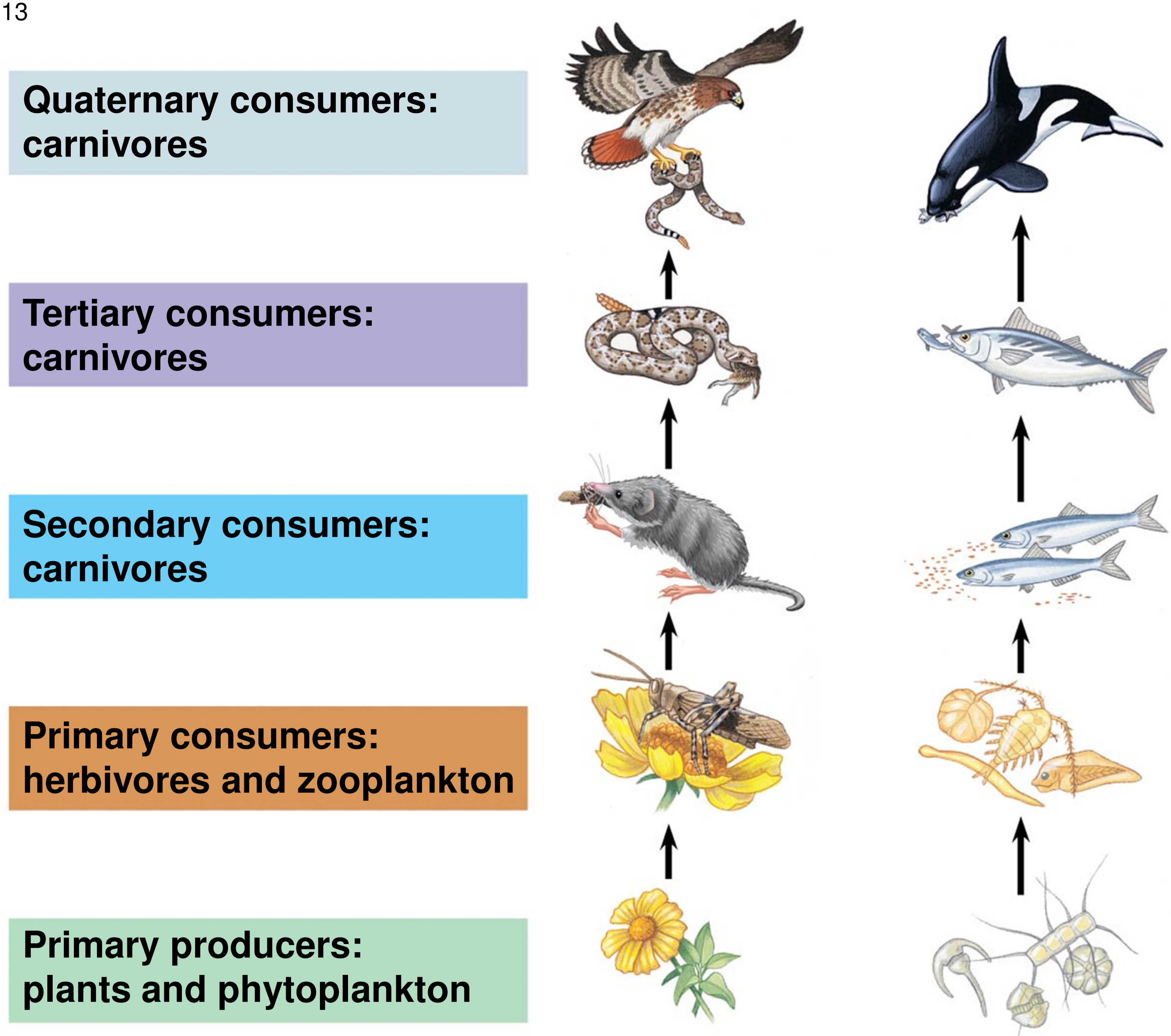
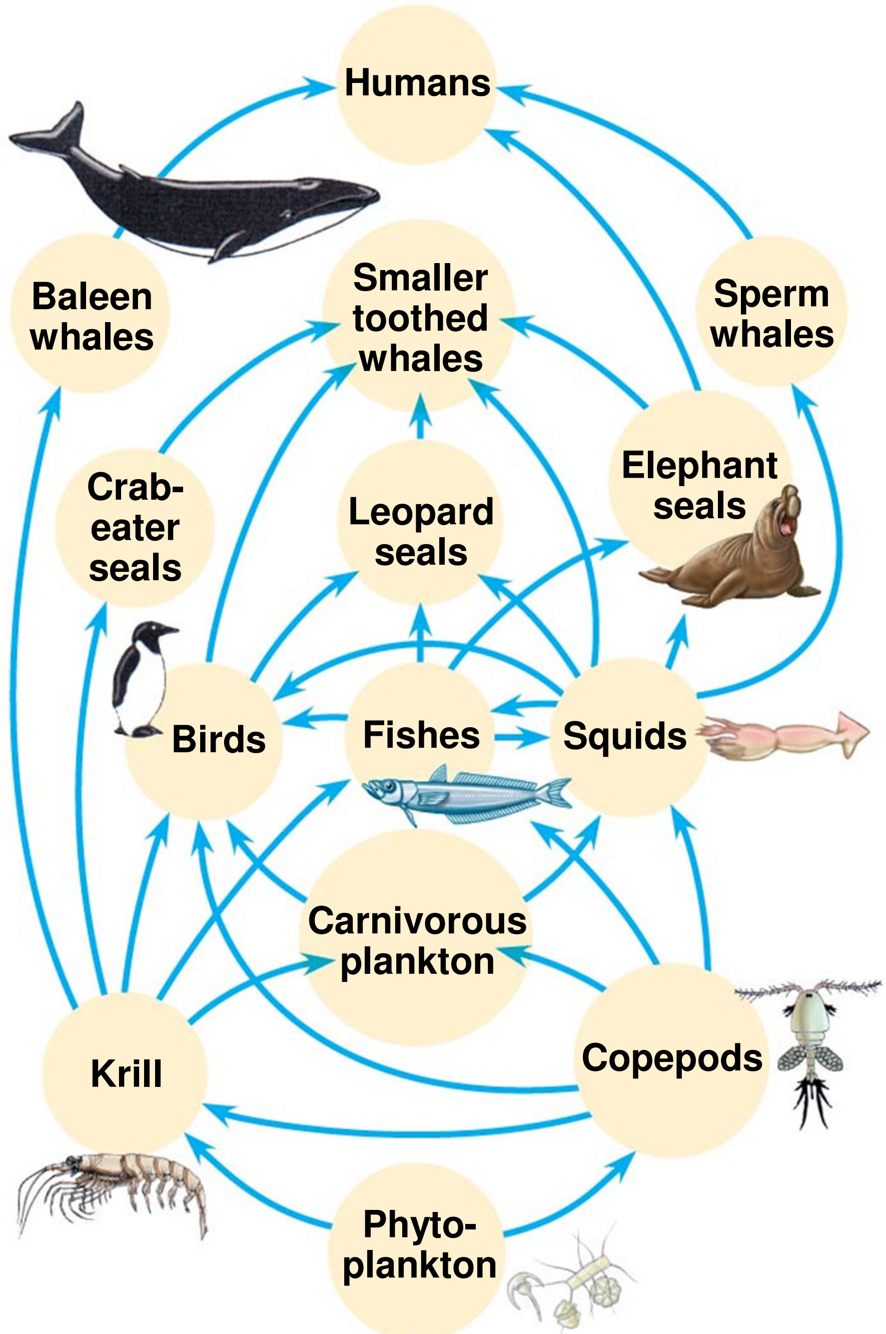

Quaternary consumers: carnivores
Tertiary consumers: carnivores
Secondary consumers: carnivores
Primary consumers: herbivores and zooplankton
Primary producers: plants and phytoplankton

Figure 41.14


Humans
Baleen whales
Smaller toothed whales
Sperm whales
Crab-eater seals
Leopard seals
Elephant seals
Birds
Fishes
Squids
Carnivorous plankton
Krill
Copepods
Phyto-plankton

Species with a Large Impact

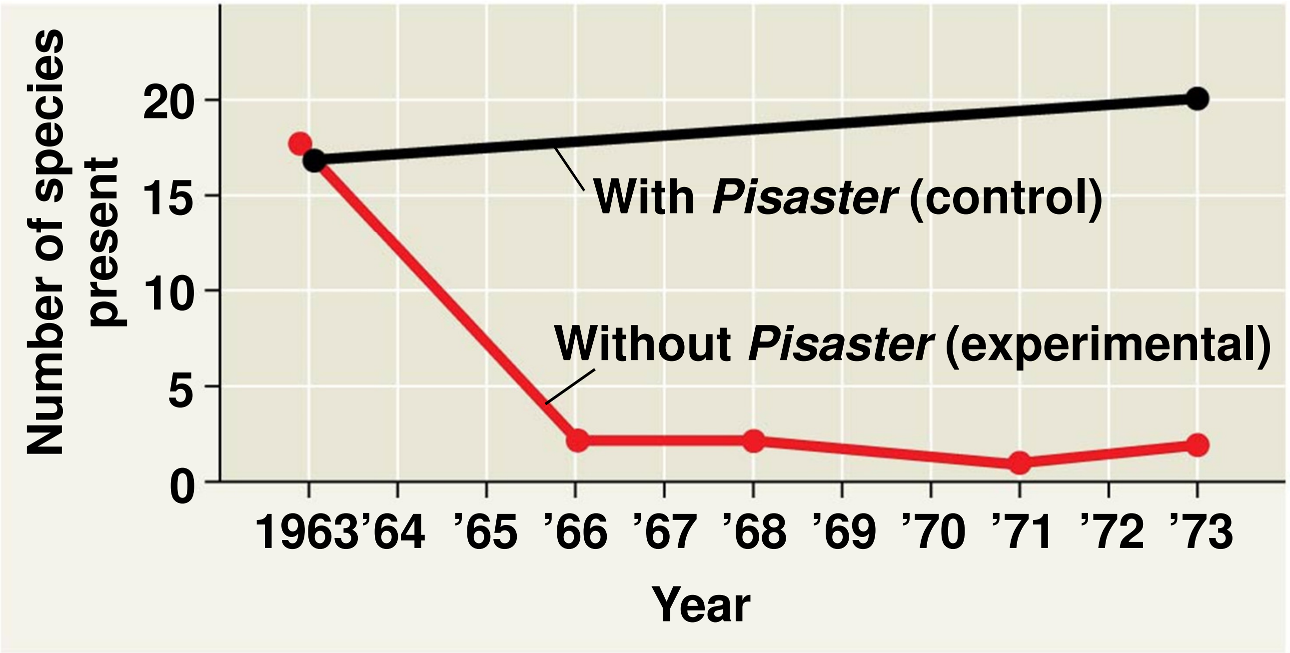
- Certain species have a very large impact on community structure
- Such species are highly abundant or play a pivotal role in community dynamics
- **Dominant species** are those that are most abundant or have the highest biomass
  - Perhaps most competitive in exploiting resources or most successful at avoiding predators and disease

- **Keystone species** exert strong control on a community by their ecological roles, or niches
  - In contrast to dominant species, they are not necessarily abundant in a community
  - Ex: Sea stars
- **Ecosystem engineers** (or "foundation species") cause physical changes in the environment that affect community structure
  - Impact could be positive or negative
  - Ex: Beaver dams can transform landscapes on a very large scale

Figure 41.15

Experiment

Results



Bottom-Up and Top-Down Controls

- The **bottom-up model** of community organization proposes a unidirectional influence from lower to higher trophic levels
- To change the community structure of a bottom-up community, you need to alter biomass at the lower tropic levels
  - Ex: Presence or absence of mineral nutrients determines community structure, including the abundance of primary producers
    - But a change in predator abundance should not extend down to lower trophic levels

- The bottom-up model can be represented by the equation

$$N \longrightarrow V \longrightarrow H \longrightarrow P$$

$N =$ mineral nutrients

$V =$ plants

$H =$ herbivores

$P =$ predators

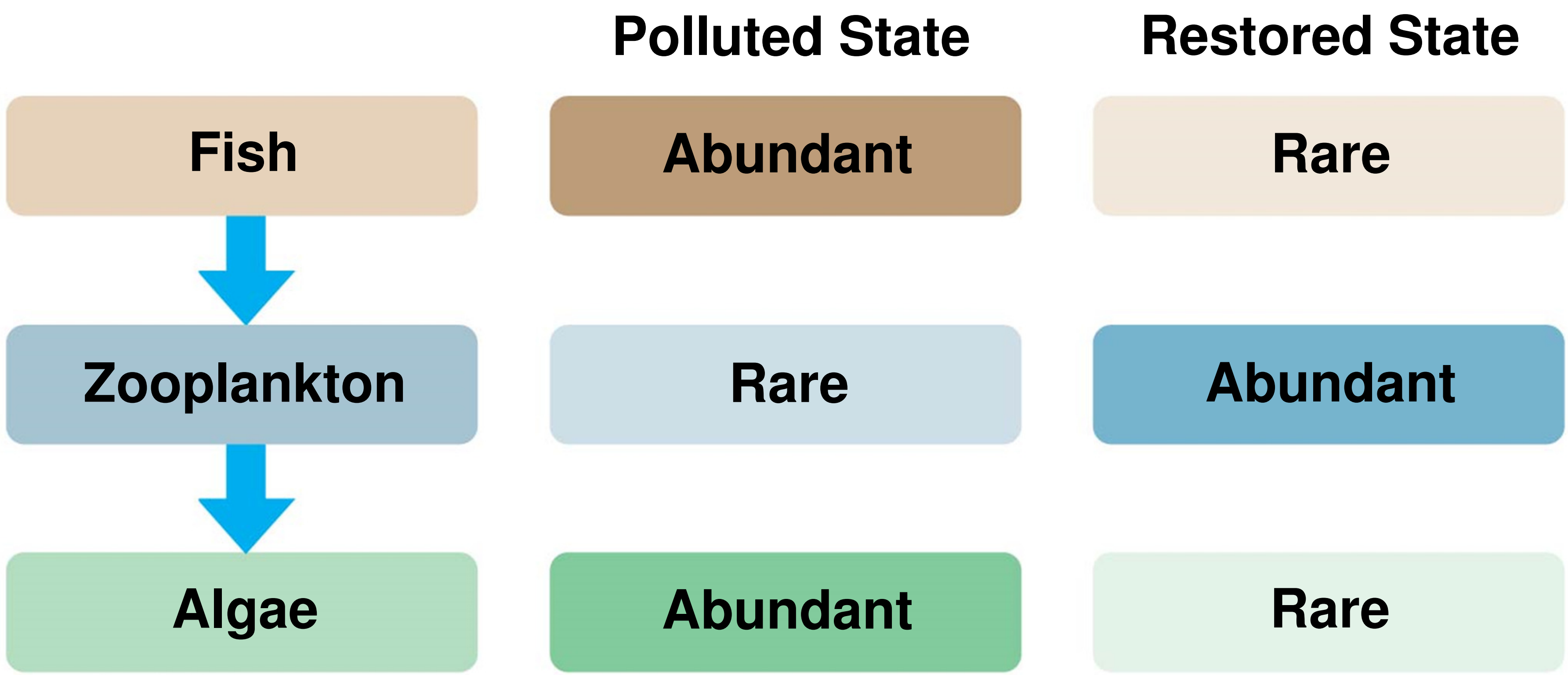
- The **top-down model**, also called the trophic cascade model, proposes that control comes from the trophic level above
- In this case, predators control herbivores, which in turn control primary producers

$$N \longleftarrow V \longleftarrow H \longleftarrow P$$

- Removing top carnivores should increase abundance of primary consumers
- This should decrease the number of herbivores
- Which should increase phytoplankton abundance
- Thus decreasing concentrations of mineral nutrients
  - Alternating +/- effects

- **Biomanipulation** applies the top-down model to alter ecosystem characteristics
  - Ex: Improve water quality in polluted lakes
    - Prevent algal blooms and eutrophication by
      - Altering density of higher-level consumers
      - Instead of using chemical treatments

Figure 41.UN02



Concept 41.3: Disturbance influences species diversity and composition

- Recent evidence of change has led to a **nonequilibrium model**
  - Communities as constantly changing after being buffeted by disturbances
- A **disturbance** is an event that changes a community, removes organisms from it, and alters resource availability
  - Ex: Storms, fires, spring flooding, and seasonal drying

Characterizing Disturbance

- A high level of disturbance is the result of a high intensity *and* high frequency of disturbance
- Low disturbance levels result from either low intensity *or* low frequency of disturbance
- The **intermediate disturbance hypothesis** suggests that moderate levels of disturbance can foster greater diversity than either high or low levels of disturbance
  - High levels of disturbance exclude many slow-growing species
  - Low levels of disturbance allow dominant species to exclude less competitive species

Ecological Succession

- **Ecological succession** is the sequence of community and ecosystem changes after a disturbance
  - **Primary succession** occurs where no soil exists when succession begins
    - New volcanic island
    - Rubble left by retreating glacier
  - **Secondary succession** begins in an area where soil remains after a disturbance
    - Fire

- Early-arriving species and later-arriving species may be linked in one of three processes
  - Early arrivals may *facilitate* the appearance of later species by making the environment favorable
  - Early species may *inhibit* the establishment of later species
  - Later species may *tolerate* conditions created by early species, but are neither helped nor hindered by them

Human Disturbance

- Humans have the greatest impact on biological communities worldwide
- Human disturbance to communities usually reduces species diversity
  - Agricultural development
  - Clear-cutting for lumber, cattle grazing, and farmland
  - Overgrazing
  - Ocean trawling

Concept 41.4: Biogeographic factors affect community diversity

- Two key factors that affect a community's species diversity are
  - Latitude of a community
    - Species richness is especially great in the tropics
      - Most likely due to evolutionary history and climate
  - Area it occupies
    - A larger geographic area has more species
    - Species richness on islands depends on island size, distance from the mainland, immigration, and extinction

Concept 41.5: Pathogens alter community structure locally and globally

- Ecological communities are universally affected by **pathogens**
  - Disease-causing organisms and viruses
- Pathogens can have dramatic effects on community structure when they are introduced into new habitats
- **Zoonotic pathogens** have been transferred from other animals to humans
- The transfer of pathogens can be direct or through an intermediate species called a **vector**
  - Vectors that spread zoonotic diseases are often parasites
  - Identifying the community of hosts and vectors for a pathogen can help prevent disease